Microscopic Evaluation of Friction Plug Welds – Correlation to a Processing Analysis

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Overview

- Utilizing friction stir welding for various flight structures
- Process leaves a hole at the end of the weld
- Plug welding used to complete structure

Overview

Video

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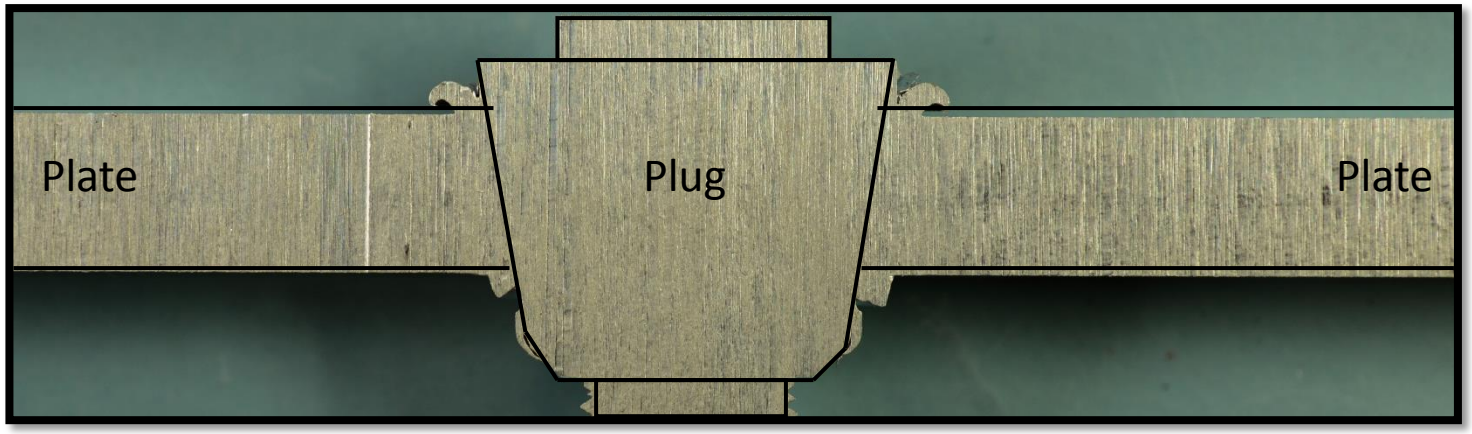
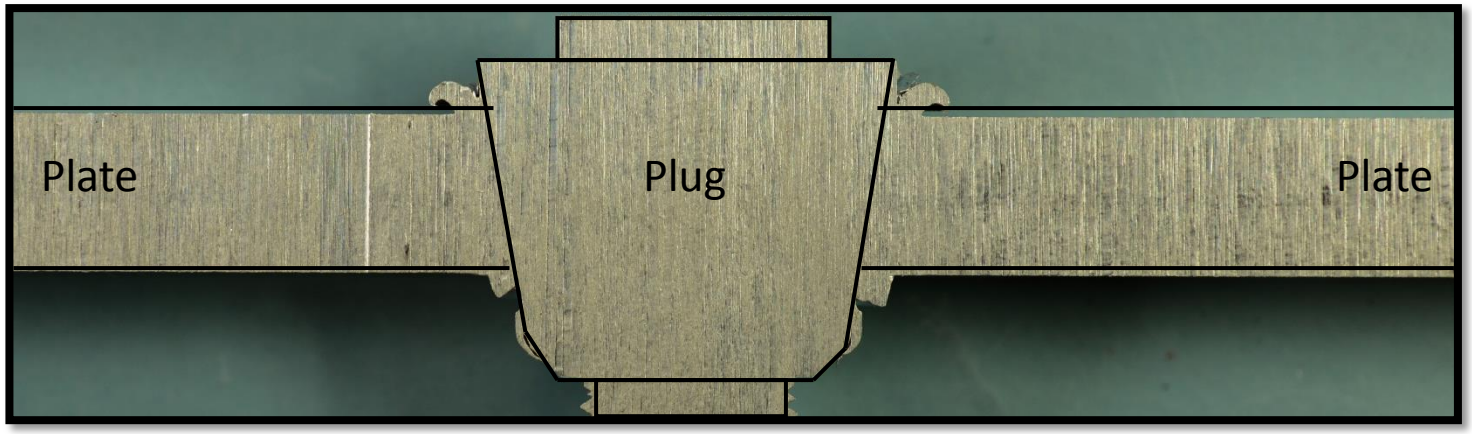


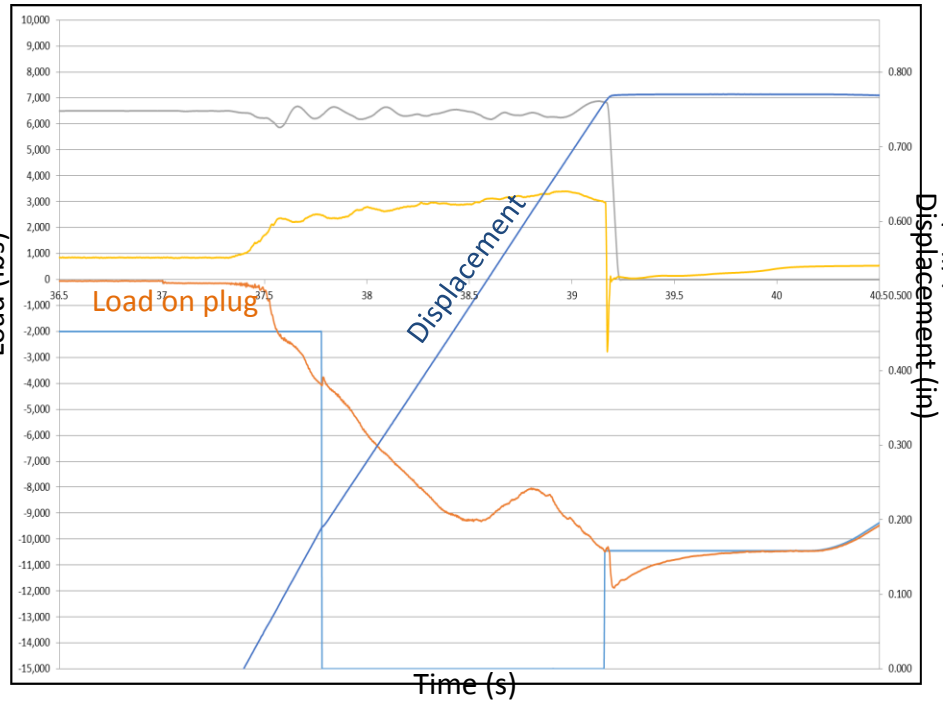
Overview

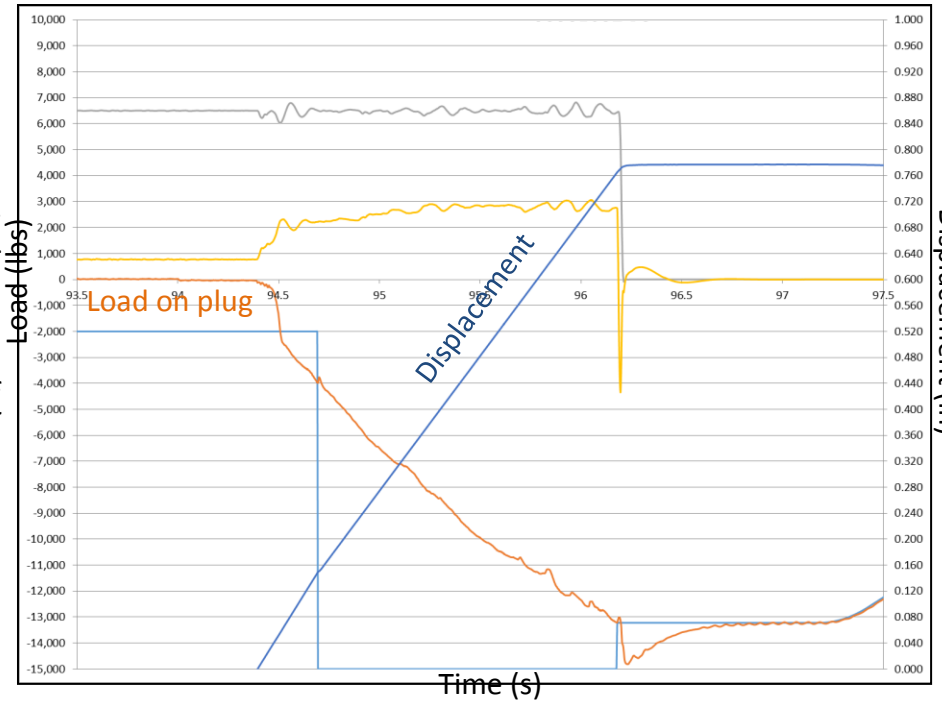
- Utilizing friction stir welding for various flight structures
- Process leaves a hole at the end of the weld
- Plug welding used to complete structure

- Need to be confident in weld quality
- Feedback analyzed to help determine whether good plugs



Feedback Data





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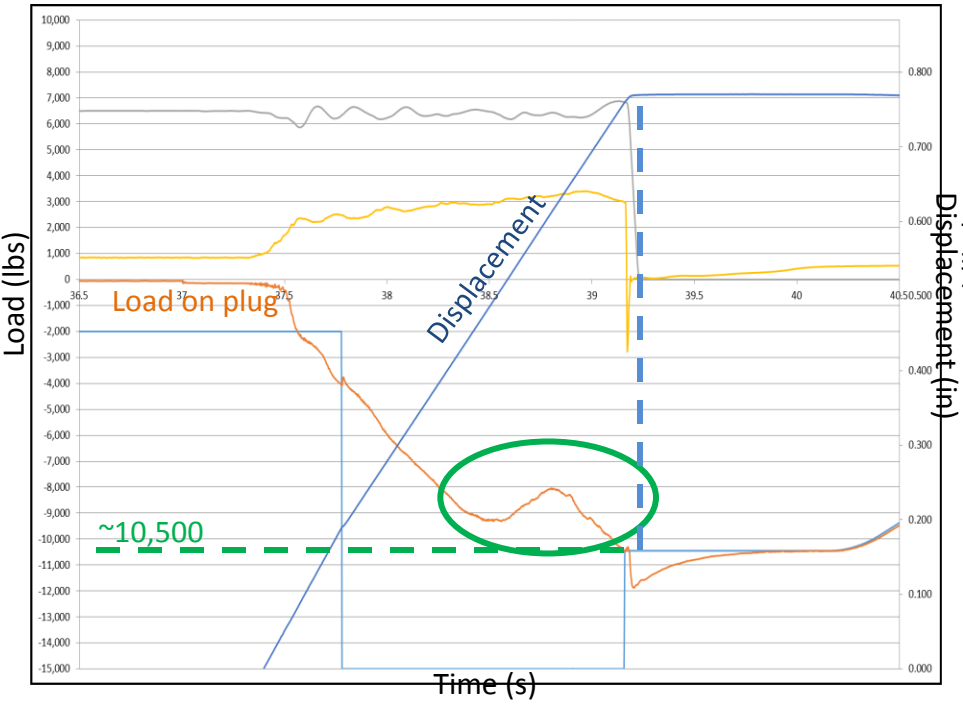
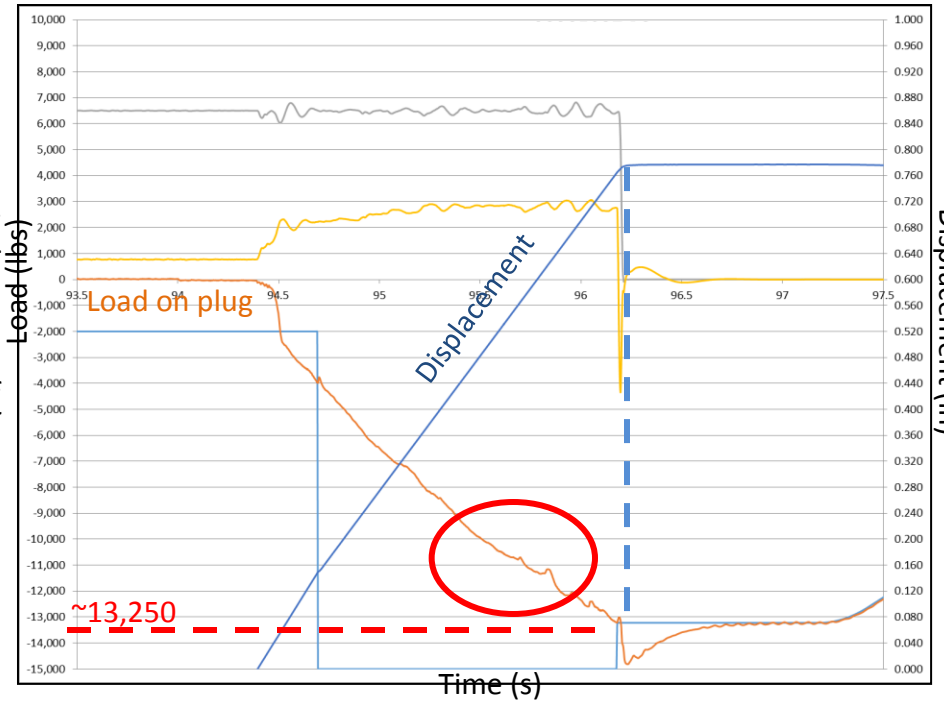
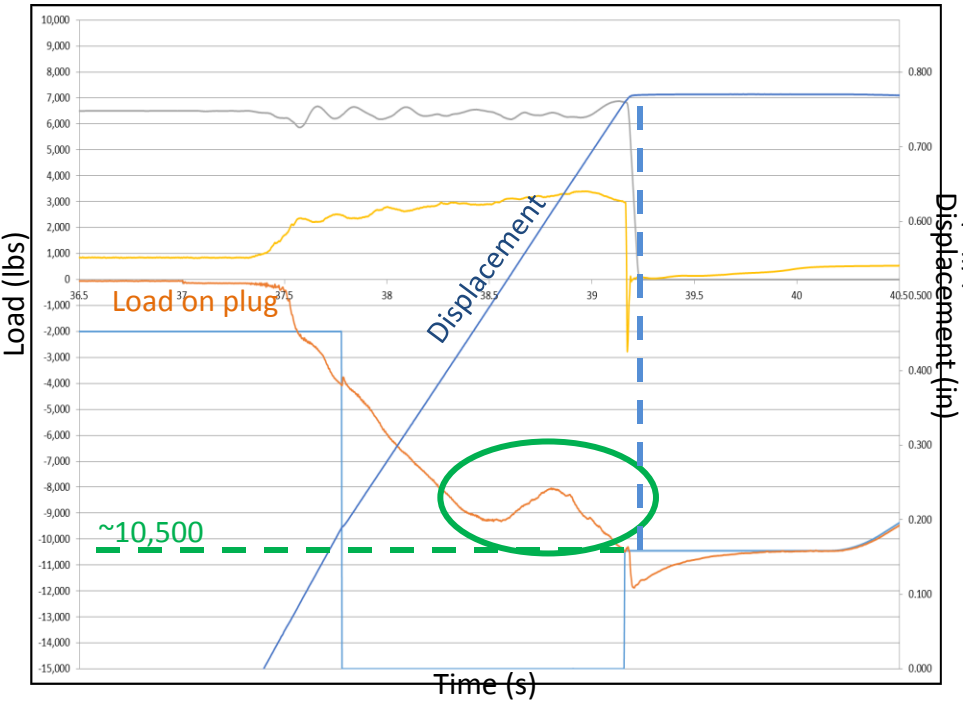
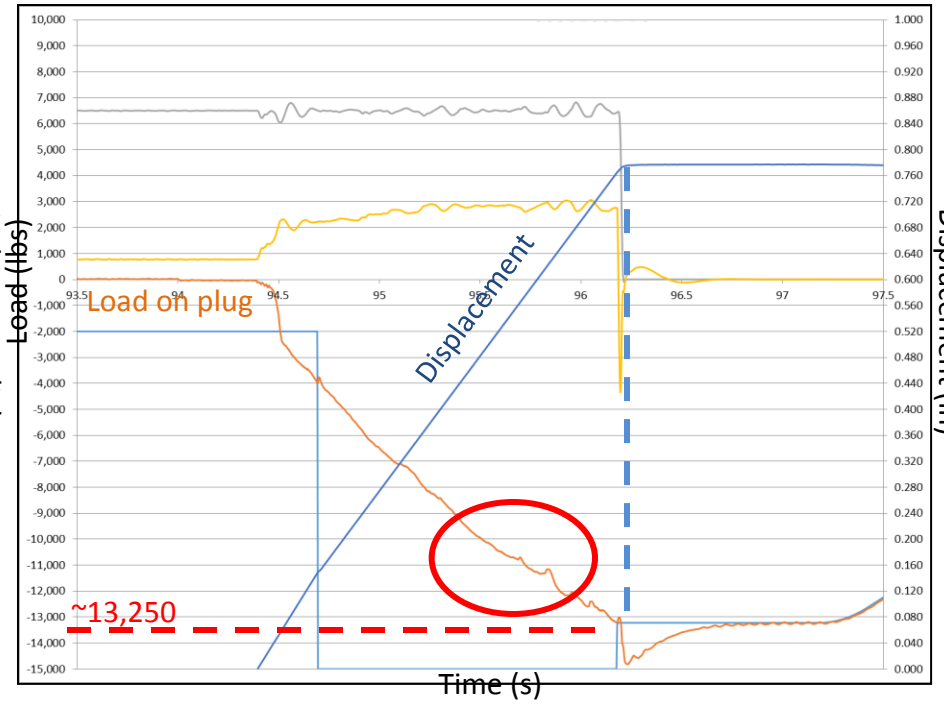


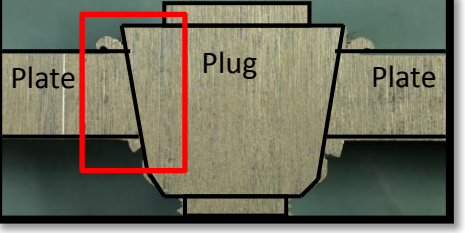


Feedback Data

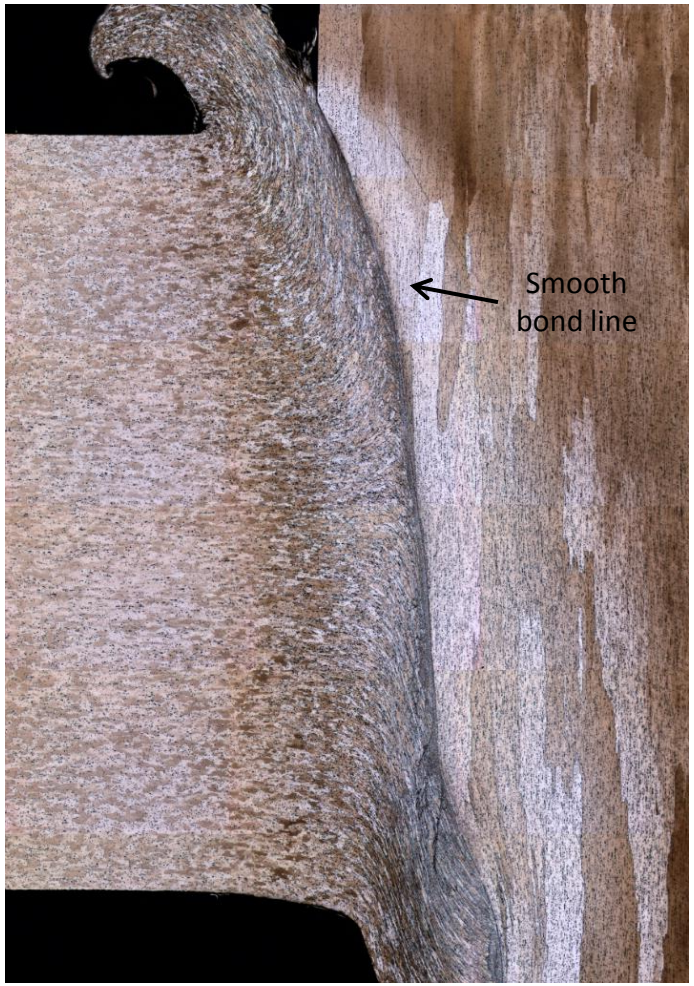


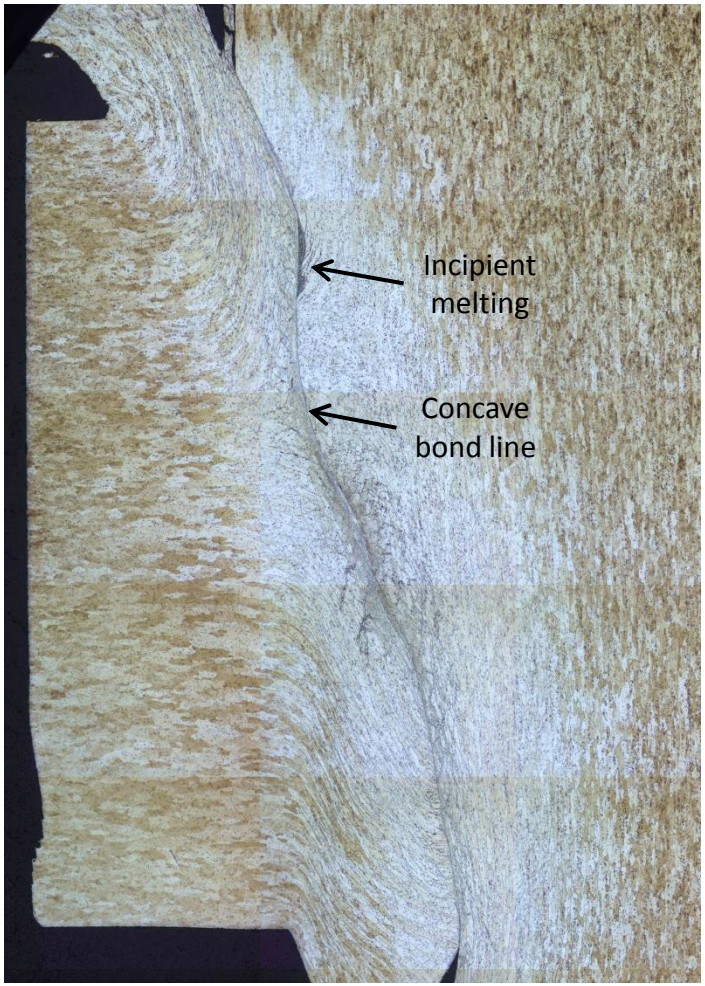


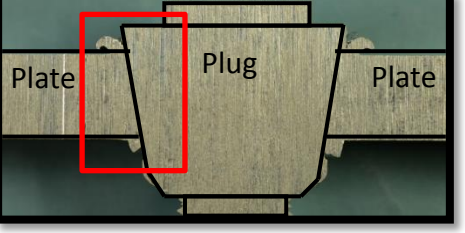
48.3 KSI Tensile stress 37.86 KSI



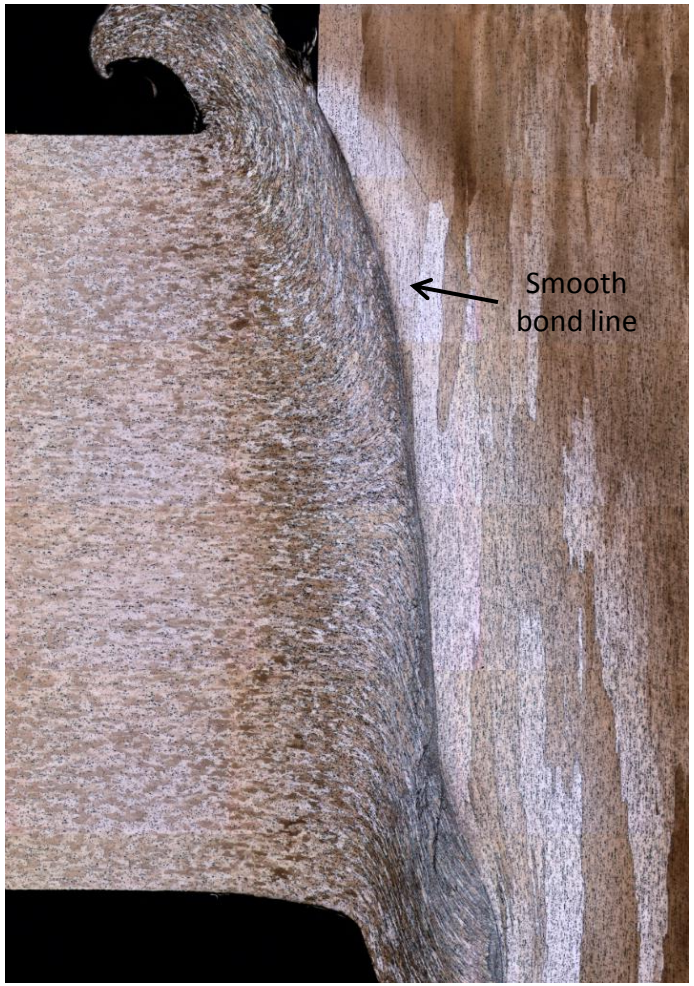
Microstructure

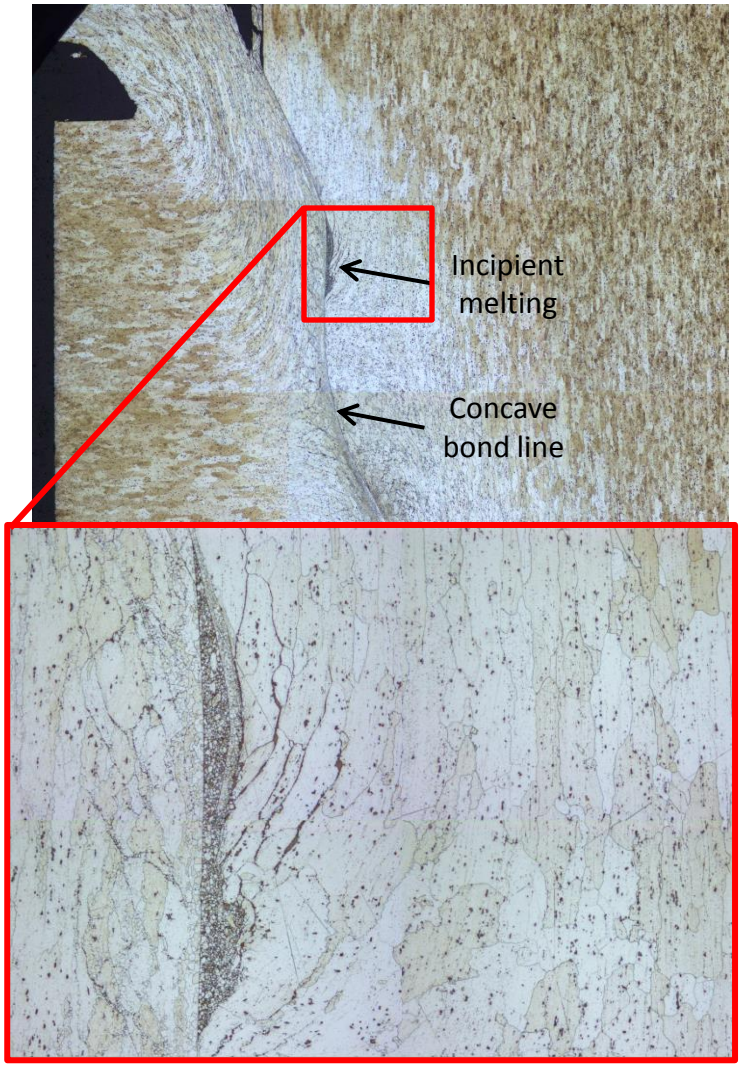






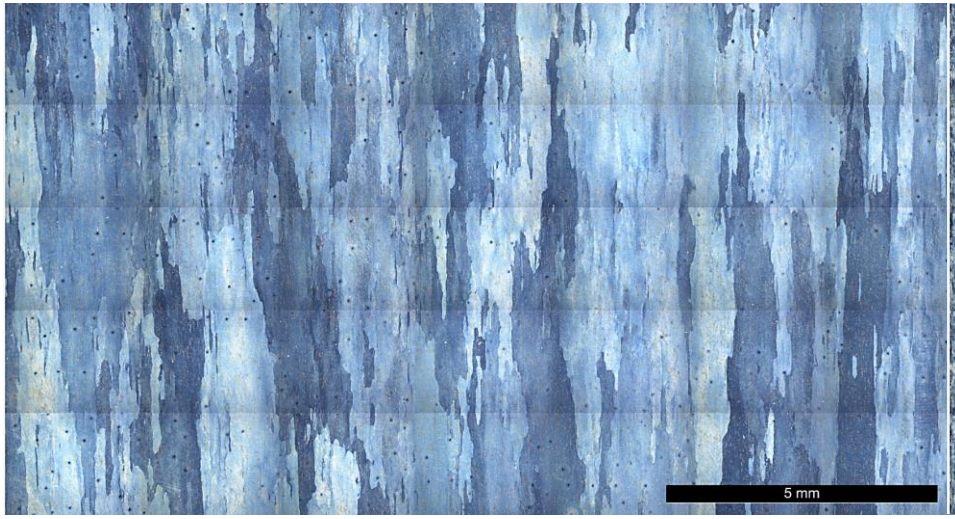
Microstructure

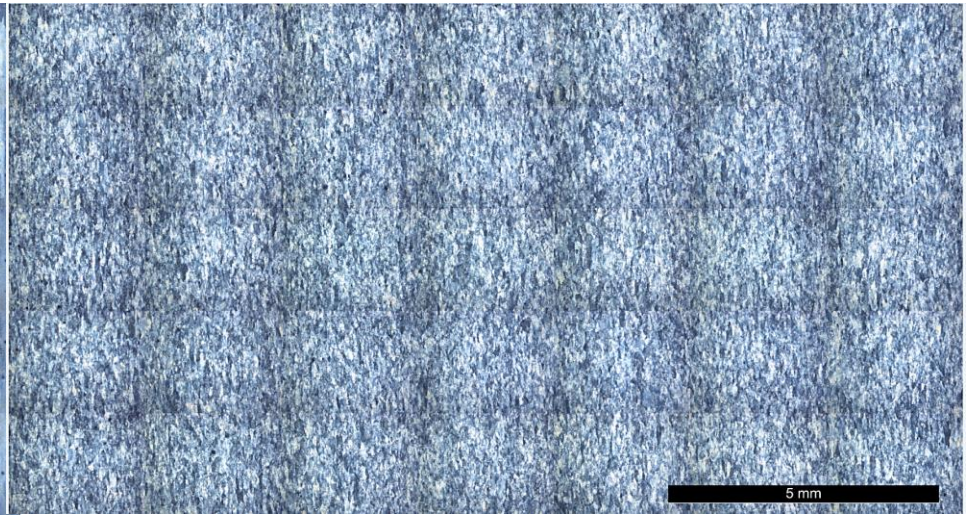


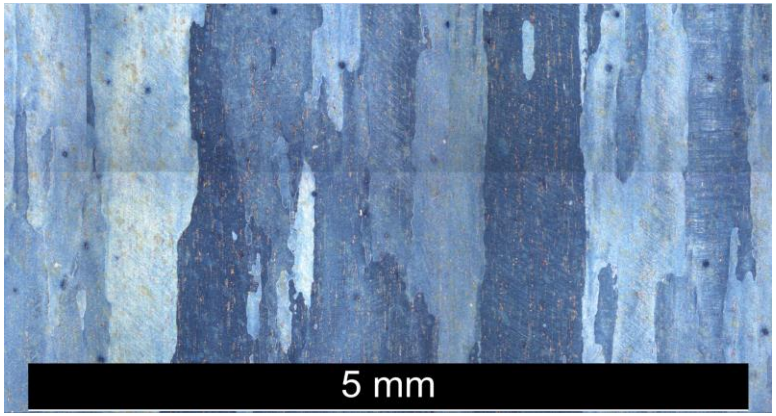


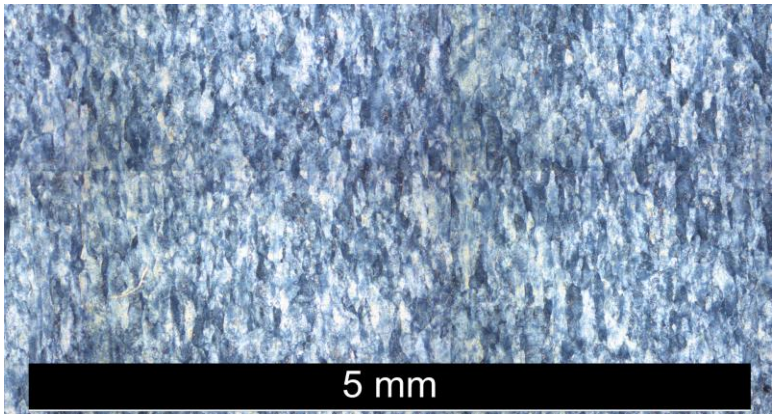
Plug Grain Structure

- Extruded 2219 Al
- Varying heat lots





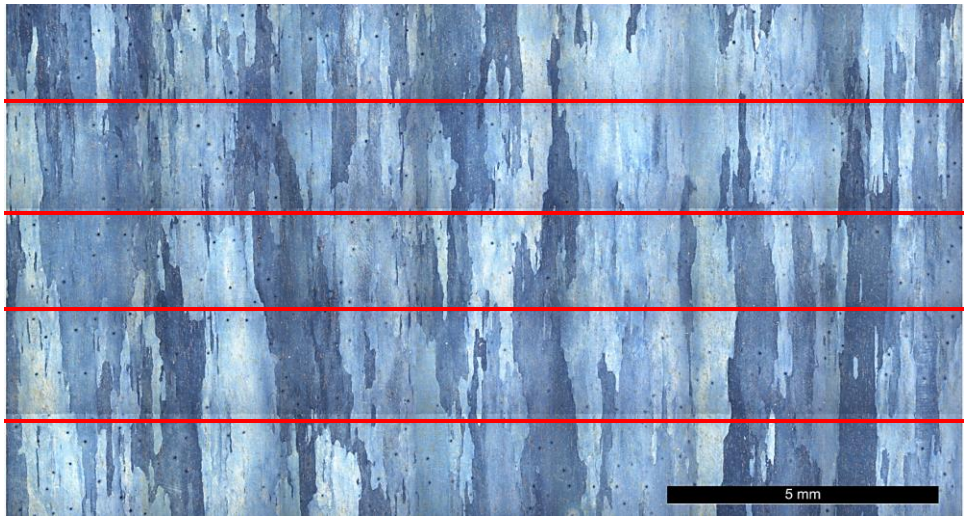


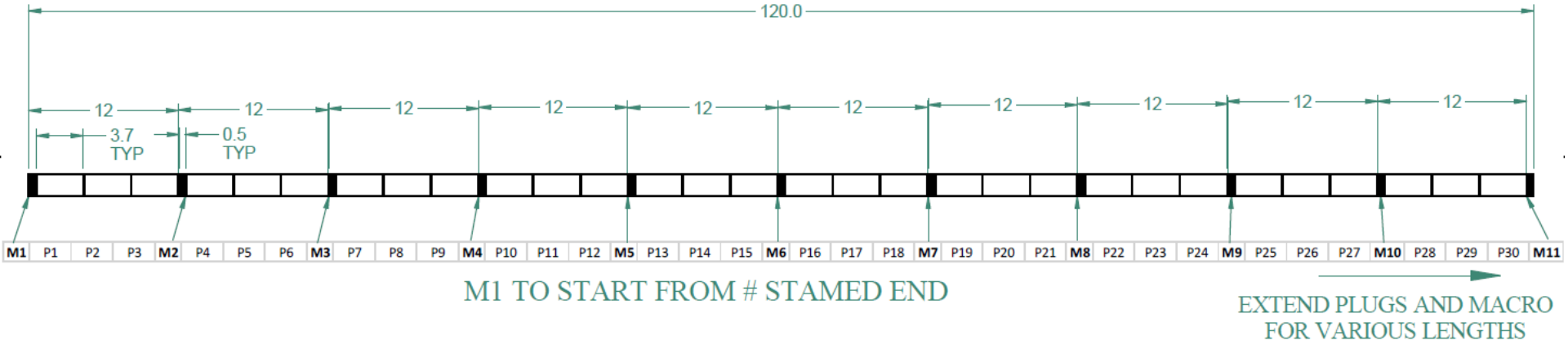


Grain Size Determinations

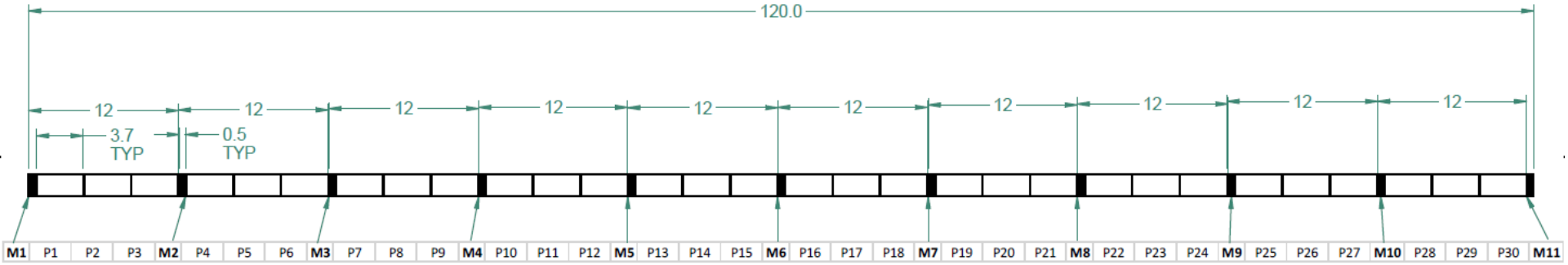
- **Grain size determination of specimens with non-equiaxed grain shapes per ASTM E112-13**
- 16.3 Intercept Method
  - 16.3.2 The grain size can be determined from measurements of (1) the mean number of grain boundary intersections per unit length, or (2) the mean number of grains intercepted per unit length.

- Both methods yield the same results for a single phase grain structure. The measurement can be made using (1) either test circles (for aspect ratio < 3:1) on each of the principal planes or (2) directed test lines in either three or six of the principal test directions.



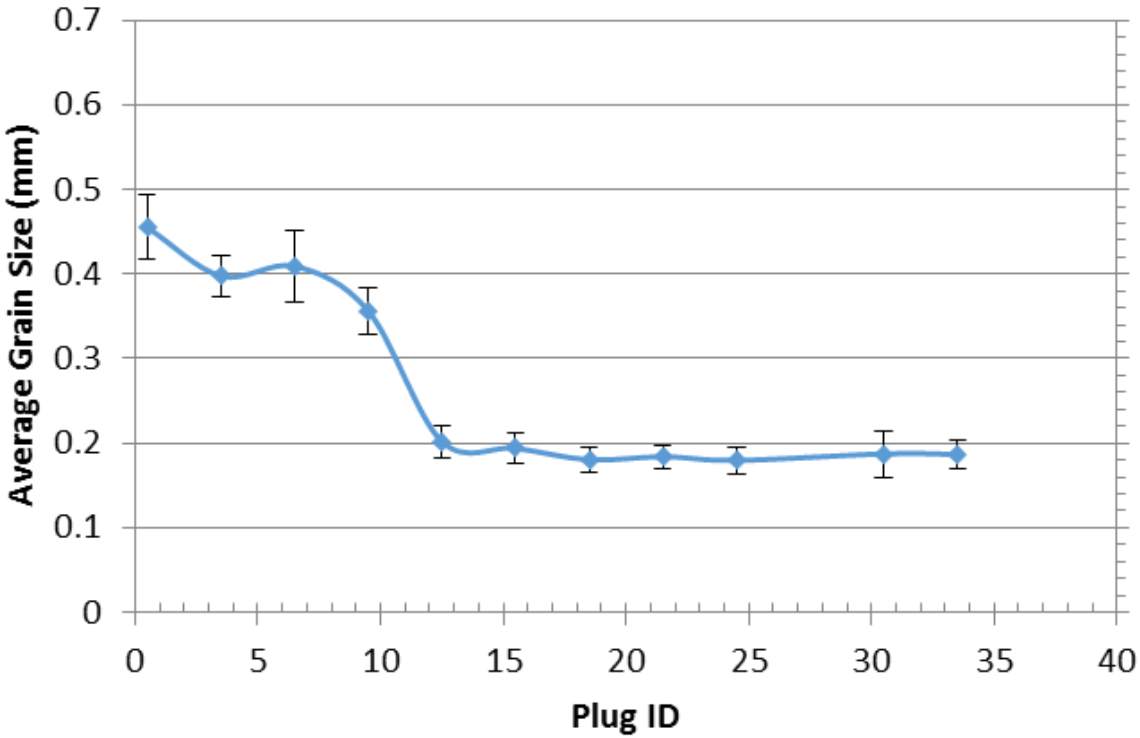


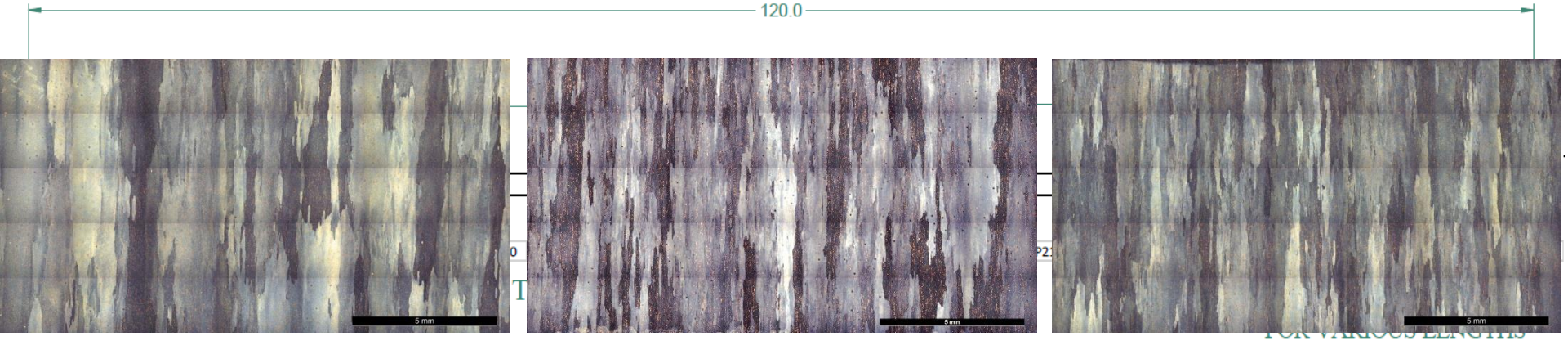
- Plugs machined from extruded 2219 rods
- Questions:
  - How much good material available?
  - Is grain size consistent within single rod?
  - How do properties change?
- Systematically analyzed single rod
  - Metallography/grain size
  - Feedback
  - Tensile strength

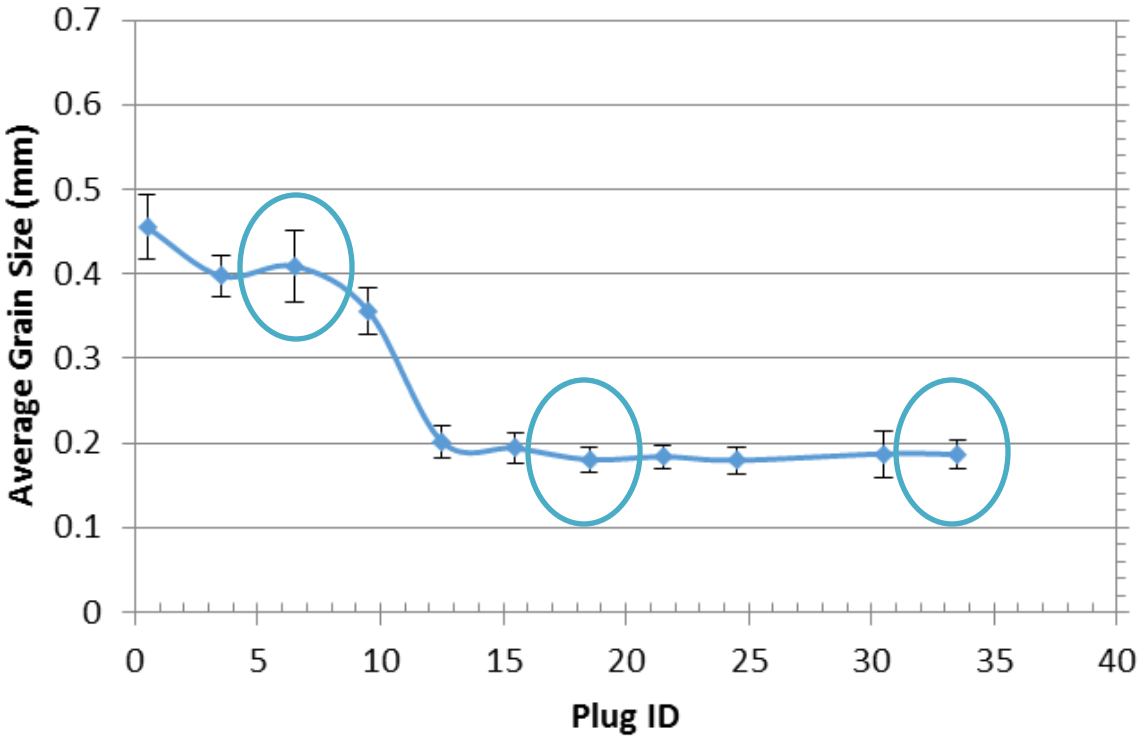


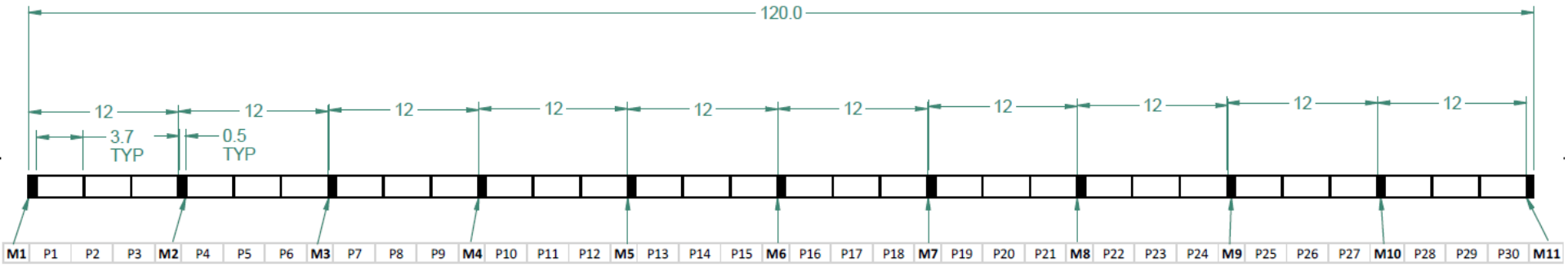
M1 TO START FROM # STAMED END

EXTEND PLUGS AND MACRO FOR VARIOUS LENGTHS




120.0
5 mm
5 mm
5 mm


Average Grain Size (mm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40
Plug ID



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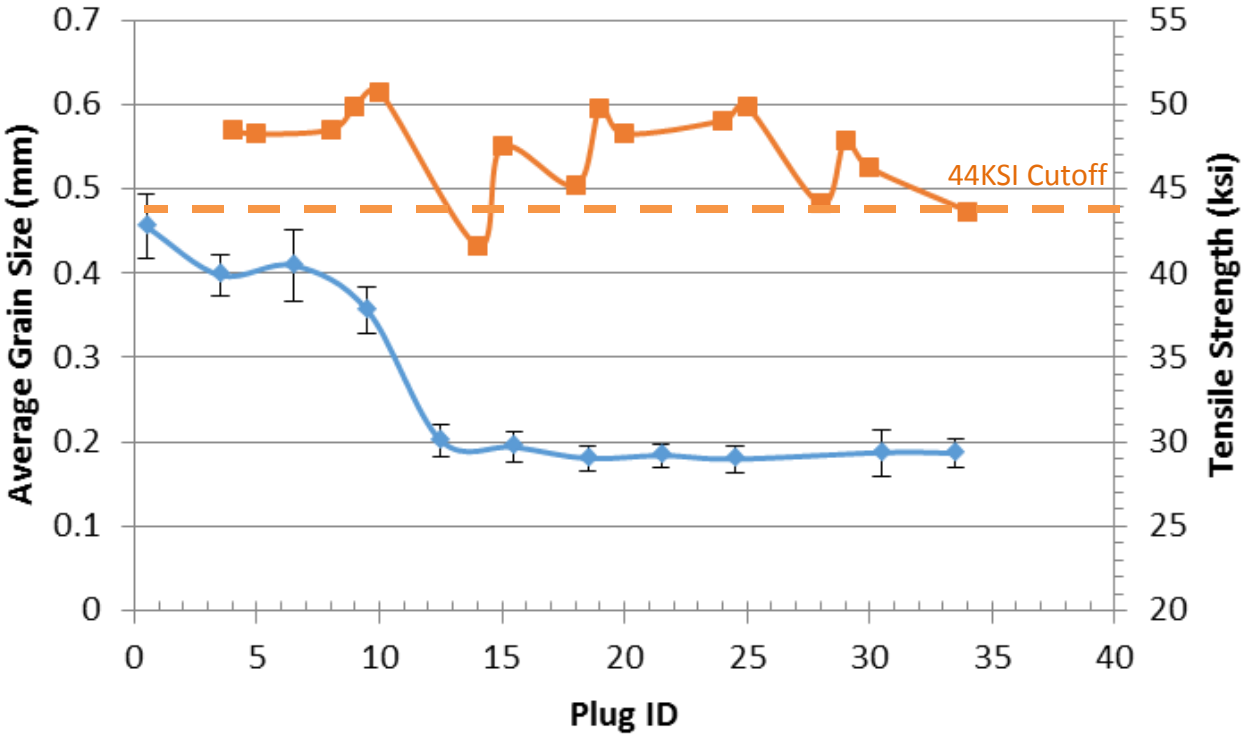

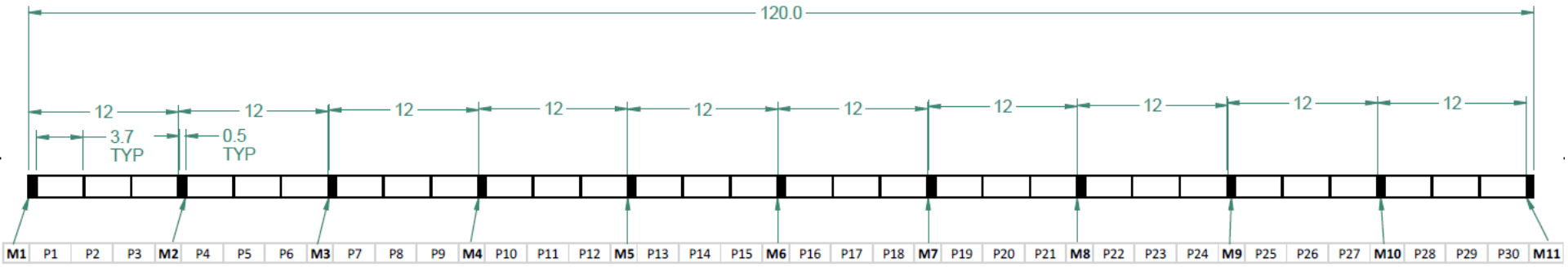

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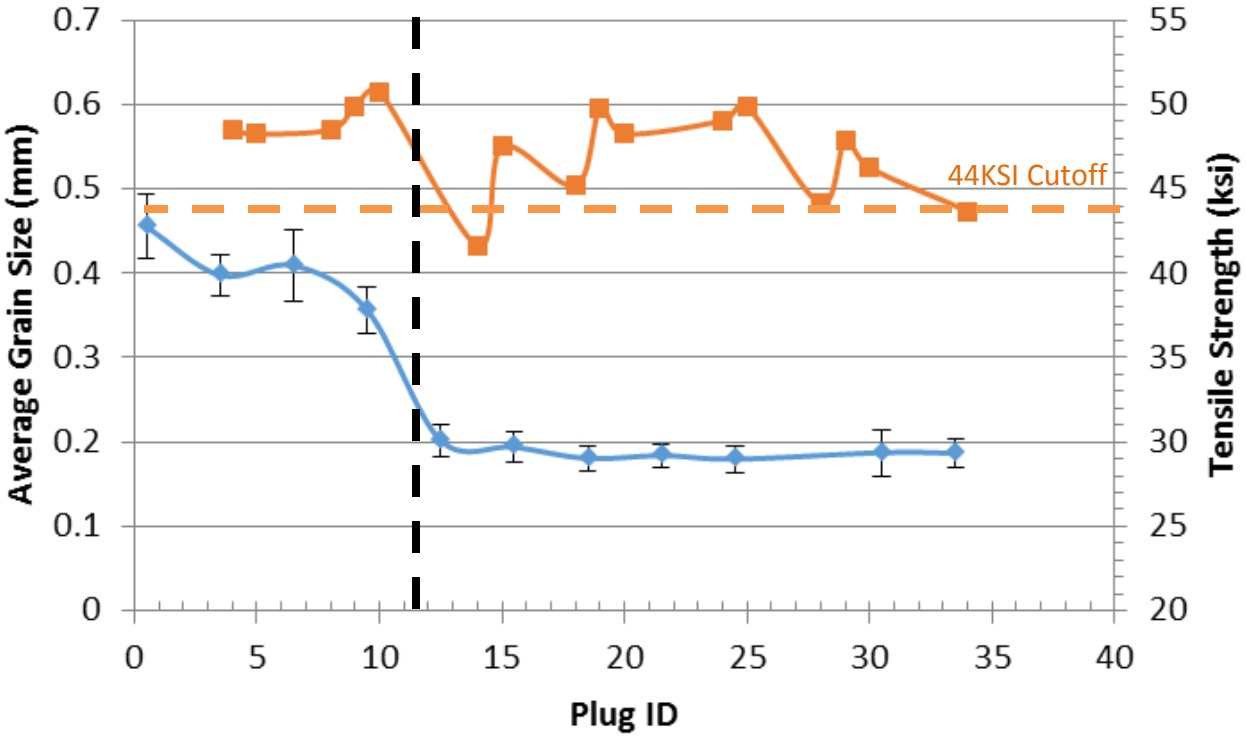

Summary

- Obtaining inconsistent feedback data and corresponding tensile strengths
- Recognized smaller grain sizes correlate to undesirable plug properties

- Working on screening methods to easily identify plugs that consistently provide good properties

Backup

Bond Line Evolution for FPPW (Various depth)